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The Development of Modules for the Support of Education in the field of Biomedical Engineering

V. Djordjevic, V. Gerla, M. Huptych, L. Lhotska, V. Krajca
Gerstner Laboratory, Faculty of Electrical Engineering, Czech Technical University in Prague, Technicka 2, Prague, Czech Republic, phone: +420 22435 7609, e–mail: djordvla@fel.cvut.cz

Introduction

The term interdisciplinary education today is used to describe studies that combine several established fields of science. It focuses on problems thought to be complex for adequate understanding with a single discipline. The interdisciplinary approach in general is already considered to be common in scientific and industrial communities. Hence, it connects researchers and experts from completely different fields of science and engineering. One of the strong interconnections is between engineering and medical sciences, resulting in a wide field of biomedical engineering (BME). BME in fact comprises a lot more: data processing, computer science, physics, mathematics, electronics, material science, artificial intelligence, neurology, anatomy, chemistry, physiology, psychology. From this point of view, it is clear that interdisciplinary approach allows students to get more than one point of view on the same topic - with information provided by separate disciplines, new information appear.

In this paper we would like to present the development of the multimedia modules for the support and improvement of education in the field of biomedical engineering. Modules are primary intended to be used by university undergraduate and graduate students in the area of electrical and information engineering. With the use of information and communication technologies (ICTs) in the educational domain, educational opportunities are brought to a wider group of people, e.g. enrolled in lifelong education.

Electroencephalography (EEG) and electrocardiography (ECG) are typical representatives and important topics in the field of BME. The module about EEG is already developed. Currently, it is accessible to a number of undergraduate students in the area of electrical and information engineering. In parallel, we are starting with the development of the module with the same structure about ECG.

The rest of the paper is organized as follows. The next section will explain the structure and content of already realized multimedia module. Following section will provide evaluation and feedback information about the material. Further on, the design of new modules will be discussed together with applications and potential users. In the final section of the paper, some concluding remarks will be given.

Starting module

Electroencephalography is the measurement of spontaneous brain electrical activity by means of electrodes positioned on the scalp. It has important applications in medicine and cognitive science [1]. Due to its importance in the field of biomedical engineering, it was chosen as topic for a starting multimedia module. The EEG signal is considered to be the most complex signal of the human body, and the methodology of its processing can be also applied to other 1D signals, not necessary biological.

The multimedia material is divided into three main parts: the first one is theoretical, the second encompasses examples and tasks realized in Matlab, and the third shows how the measurement in non-medical institution is conducted. Fig. 1 represents a content of the module.

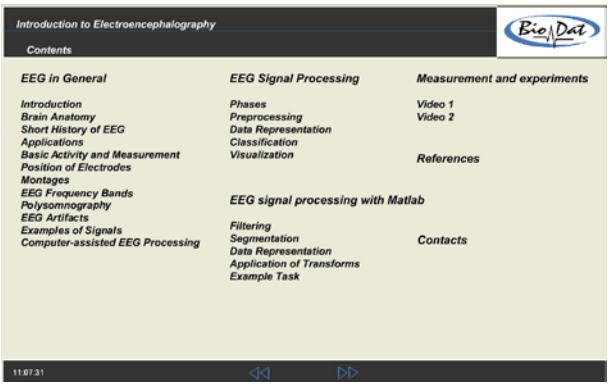
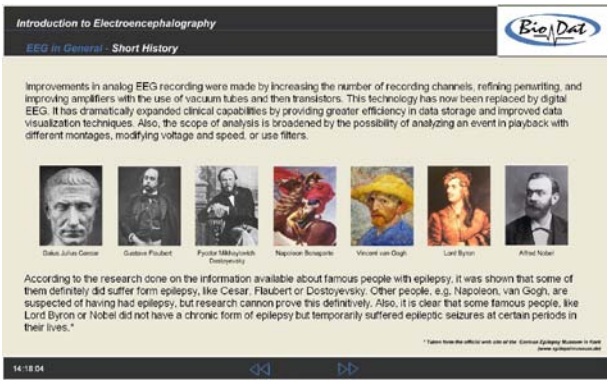


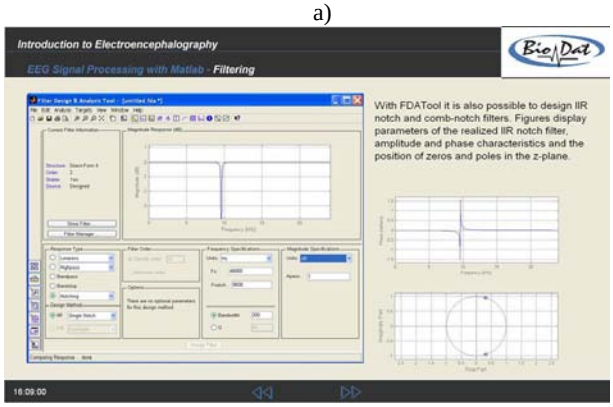
Fig. 1. Module‘s content

The theoretical part of the module is divided into two major parts and contains the most important issues

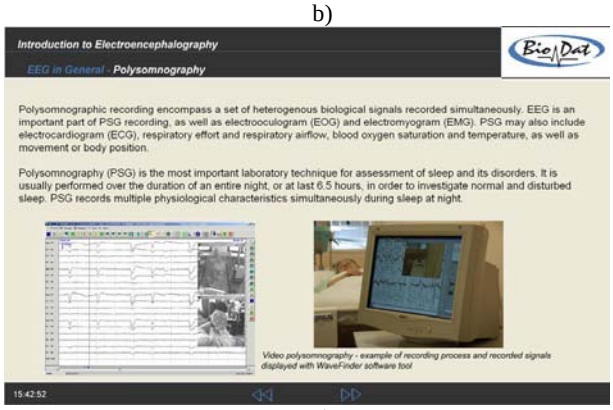
about EEG and signal processing, prepared in understandable and appropriate form for university students [2] – [6]. Fig. 2 provide screenshots of material parts as examples of the realized material.



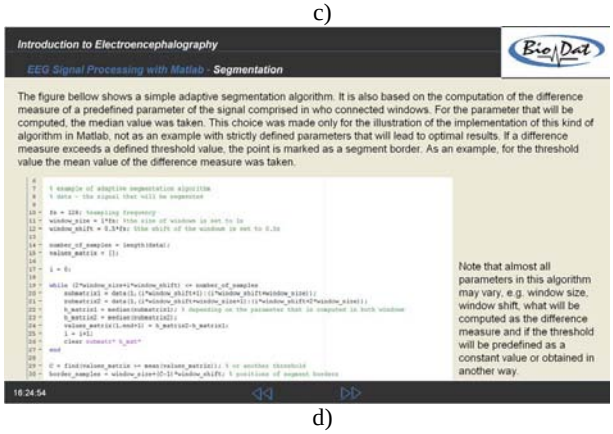
a)



b)



c)



d)

Fig. 2. Screenshots of the realized module: a – historical facts; b – example of Matlab graphical user interface application; c – polysomnographic measurement; d – example code in Matlab

Throughout the explanation of fundamental concepts, examples and example task in the second part of the module users get familiar with basic signal filtering, segmentation, extraction of statistical features or with signals in time and frequency domain with the use of Fourier or wavelet transform [7]-[10]. Basic content of this section was chosen according to topics comprised in courses Introduction to Biomedical Engineering, in Bachelor study, and Cognitive Systems, which is part of accredited Master study program Biomedical Engineering at the Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University in Prague. Included examples are performed on clinical data from cooperating medical institutions. Matlab was chosen due to its wide application in education but also in experimental and research area. All these facts make this material more convenient for students, allowing them to prepare for laboratory work, get familiar with EEG signal and problems of its processing [11].

Also, this section introduces users with various software tools used for EEG signal displaying, processing and visualization, namely Wavefinder [12] and EEGLab[13], or for classification, e.g. Weka [14]. This is important because users are introduced to the state of the art software tools that are actually used in clinical practice by medical doctors and in research.

Examples of electroencefalographic and polysomnographic (PSG) recordings from medical and non-medical practice are also encompassed in the firts two parts of the material. Signals are visualized in their raw form as well as after the application of some steps from the introduced signal processing process.

The last part of the material shows, by means of recorded videos, how the EEG measurement is prepared and conducted in non-medical institution for educational and research purposes. This way, students are introduced to the measuring process so that in laboratory work they can interact more actively. Also, this kind of material is useful for users that do not have the opportunity to participate in measurement demonstration.

Framework for multimedia material is realized in Adobe Flash. In cooperation with psychologist, the appropriate form of multimedia material for students and education was designed. Also, attention was given to the choice of background and foreground colors, to ensure that they provide sufficient contrast and that all the elements in material are perceivable. The whole approach was designed in such way that it can be applied not only to EEG but also to other topics in biomedical engineering. New trends in this field or changes can be easily incorporated due to the open structure of the realized material. The first version of a module was already enlarged by parts of students' diploma works and codes.

Evaluation

The first module in the field of biomedical engineering concerning electroencephalography was implemented as a project of the University Development Foundation of Czech Republic. The project was reviewed by two reviewers and the complete module was presented to the commission of experts from this institution.

Some of the questions that were answered by reviewers in the process of evaluation concerned the financial part of the project, while others were meant to reveal the quality of the realized material and its application in education. The project results in comparison with established objectives and the usability of the project for the development of education were commented. The achievement of project objectives was fulfilled regarding both reviewers, and as positive sides of the project its informativity, form and wide field of potential users were listed. Regarding the usability of the material in the educational domain, reviewers pointed out that its possible application is also at medical faculties (with minor changes in the material) for the enhancement of education. This way, the module could become a means of interdisciplinary communication.

The complete evaluation result from the University Development Foundation of Czech Republic was positive.

Currently, this module is accessible to a number of undergraduate students in the area of electrical and information engineering. During the period of one semester, we are gathering the students' feedback regarding their satisfaction with respect to this module. It will provide us some statistics regarding the students number, their satisfaction with the module, efficiency, quality, etc. For this purpose, a questionnaire for students was designed. Filling up the questionnaire is not obligatory, it is anonimous and it can be supplemented with comments. Questions are about:

- The ability of the material to hold attention,
- If texts and codes are in the understandable form,
- The usefulness of the material for laboratory work and lectures,
- Changing of the content – adding/removing module parts,
- Possible use of the material in the future,
- Support of this kind of educational material and if more material in this form is welcome.

As already mentioned, some of the changes were already introduced to the starting version of the module. They consisted of adding material mainly to its second part, concerning examples and tasks in Matlab. The added material encompasses students' work and codes.

New modules

As already mentioned, the whole approach was designed in such way that it can be applied not only to electroencephalography but also to other topics in biomedical engineering.

The module with the same structure about electrocardiography is under development. Electrocardiographic signal is the biosignal of the heart. Potentials of cardiac muscle cells provide the base for ECG signal formation. The ECG is widely used noninvasive technique mostly used in diagnosing cardiac deseases (e.g. arrhythmias or myocardial infarctions). Because of the fact that electrical events always precede mechanical events in the cardiac cycle, distortion of a part or parts of the electrical signal have been used as diagnostic indicators of both electrical and mechanical dysfunctions of the heart muscle [15]. Some of the topics that will be covered by this module are: heart and its function, recording of ECG (including history, systems for positioning of surface electrodes, vectorcardiography), ECG visualization methods, holter monitoring, and ECG artifacts. The topics encompassed in computer based ECG signal processing are also planed to be included in the module.

Further development of new modules could be oriented to medical devices available for students in non-medical environment, e.g. spirometer and body composition analyzer, their theoretical background, technical characteristics and medical applications. Another possible topic is the design of experiments in the field of biomedical engineering.

Application

At the beginning of the development of our education modules in the field of biomedical engineering, target users were undergraduate and graduate students of electrical or information engineering. Due to the nature of this interdisciplinary field and ICTs today, it is clear that the spectrum of subjects possibly interested in this material could be quite wide, considering different occupations, background and interests on one side, and age structure on the other.

Also, students with medical background can find it interesting and useful for inspecting technical part of the electroencephalography. In higher education it can be used as informative material for introduction to topics in this area and as material for motivating students to continue their education in this direction. On the other hand, it can be used also in lifelong education. It is appropriate for people who are professionally involved in this field, as a good way for their personal improvement and staying in touch with novelties and trends. Moreover, it can be used by professionals working in healthcare, in the area of biomedical signal processing, that have to participate in professional lifelong education.

The module about EEG is available at http://bio.felk.cvut.cz/eegintro. It is in use, for example, as a support tool in the course Introduction to Biomedical Engineering in the Bachelor study program at our faculty. The maintenance and development of modules in the future are sustainable due to the fact that appropriate study programmes have valid accreditation at least till the end of the year 2013.

In the future, excellent and complete application of our material would be through an International Module course (IM course). IM courses are available to the wide range of users over the ELLEIEC project web portal http://www.elleiec.eu.

Conclusions

Currently, the first realized module is available to students at the Faculty of Electrical Engineering, Czech Technical University in Prague. Students from several courses, which encompass biological signals and their processing, may find this concrete module about electroencephalography useful. Various topics in a module are presented in a structured way, covering all important

topics in targeted interdisciplinary field. Modules that are to be developed will follow the same structure and will increase attractiveness of university courses in the field of biomedical engineering.

The content and form of the developed material is evaluated both by students and University Development Foundation of Czech Republic. Due to the open structure of the material, novelties and new trends can be easily incorporated. Also, part of diploma works, codes or other material provided by students can be added.

The multimedia material as a whole is meant to be used as educational support but also as a motivation tool. Emphasis was put to providing sufficient amount of theoretical and practical information in order to make students capable of understanding and conducting several signal processing steps on their own. This way, they are motivated to try to do analysis on their own, not just to perceive visualized results.

Not only university students in the field of electrical and information engineering are potential users of multimedia modules. Modules will be accessible to the wider range of users, with different educational background, occupations, interests and age.

Acknowledgement

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The goal of this paper is to present the development of the multimedia modules for the support and improvement of education in the field of biomedical engineering. The module about electroencephalography, an important topic in this field, is already developed. This module was implemented and positively evaluated by University Development Foundation of Czech Republic. Currently, this module is accessible to a number of undergraduate students in the area of electrical and information engineering. In parallel, we started with the development of the module about electrocardiography. Modules will be accessible to a wide range of users - with different education background or enrolled in lifelong education. Ill. 2, bibl. 15 (in English; abstracts in English, Russian and Lithuanian).

В. Дьордьевич, В. Герла, М. Хуптих, Л. Лхотска, В. Крайца. Введение новых модулей по изучению биомедицинских специальностей // Электроника и электротехника. – Каунас: Технология, 2010. – № 6(102). – С. 47–50.

Описывается новый модуль специальности биомедицинской инженерии. Предлагаемый модуль введен в университетах Чехии при подготовке специалистов информатики и электроинженерии. Даны рекомендации по включению таких модулей в процесс обучение на всю жизнь. Ил. 2, библ. 15 (на английском языке; рефераты на английском, русском и литовском яз.).

V. Djordjevic, V. Gerla, M. Huptych, L. Lhotska, V. Krajca. Naujų modulių įvedimas biomedicininės inžinerijos studijų kryptyje // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 6(102). – P. 47–50.

Pristatyti multimedijos moduliai, įvesti biomedicininės inžinerijos studijų kryptyje. Sudarytas ir įdiegtas mokymo procese elektroencefalografijos studijų modulis. Čekijos Respublikoje jis teigiamai įvertintas universitetų plėtros fondo. Šiuo metu šis modulis prieinamas studentams, studijuojantiems elektros ir informatikos srities bakalauro studijose. Planuojama, kad kiti moduliai bus prieinami vis didesniam skirtingą išsilavinimą turinčių studentų skaičiui arba bus įtraukti į viso gyvenimo mokymo trukmės procesą. Il. 2, bibl. 15 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).

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